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Pit and Fissure Sealants in High Caries Risk Individuals

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Abstract:

This paper examines the evidence demonstrating the effectiveness of sealants in high caries risk children and discusses the findings of the systematic review conducted by the Research Triangle Institute/University of North Carolina (RTI/UNC) investigators. The strict RTI/UNC protocol limited the number of sealant studies that could be included in their review. This analysis expanded their criteria to permit additional methods of determining caries risk (e.g., past caries experience, less than two pairs of sound first permanent molars available/child in half-mouth designs) and outcome measures in addition to DMFS (i.e., percent sealant retention, survival rates, cost-effectiveness, changes in salivary S. *mutans* levels.) Nine clinical studies with a randomized, half-mouth, clinical trial design and seven studies with observational study designs were included. There is good evidence that sealants can be used efficaciously and effectively in high risk children as long as the sealant is retained. Sealants are more effective in preventing further caries and providing cost savings in a shorter time span if placed in children who have high rather than low caries risk.

Key words: pit and fissure sealants, dental caries, prevention, caries risk assessment

INTRODUCTION

In December 1983, the NIH hosted a consensus development conference on dental sealants in the prevention of tooth decay. (1) The panel concluded, "The placement of sealants is a highly effective means of preventing pit and fissure caries." The conclusions indicated that sealants were 100 percent effective in pits and fissures that remain completely sealed, though sealant retention declined over time. Since then, comprehensive reviews (2-4) and a meta-analysis (5) have confirmed the effectiveness of sealants and a 1994 workshop developed guidelines for their use. (6)

Is there still a need for sealants, and are they being applied?

Briefly, yes and no. Results from the 1988-94 Third National Health and Nutrition Examination Survey (NHANES-III) found that 78% of 17 year-olds have experienced dental caries. (7) Estimates indicate that 90% of dental caries in children occur in pits and fissures. (8) The high prevalence of pit and fissure caries provides the rationale for sealant use. However, according to the NHANES-III baseline utilization data for the U.S. Healthy People 2010 national health objectives (9-10), only 23% of 8 year-olds and 15% of 14 year-olds had received sealants, even though the goal for both 2000 and 2010 is to increase the utilization percentage to 50%. There are also major disparities in sealant utilization by race/ethnicity and socioeconomic status. A 1993-94 California survey found that only 11% of eight-year olds had any sealants. (11) There are prominent disparities in sealant utilization by race/ethnicity and socioeconomic status. Eight-year olds are twice as likely to receive sealants if their parents (or heads of household) have had some college education than if they never graduated from high

school, and almost three times more likely to receive sealants if they are non-Hispanic White rather than Mexican-American or African-American. (7) A recent General Accounting Office report indicated that among children ages 6-14, 12% of those living at or below the federal poverty level had any sealant compared to 40% of high income families (>400% of the federal poverty level). (12)

Why are we concerned about applying sealants to high caries risk children?

An early sealant philosophy was to apply sealants to all children and all teeth with pits and fissures. We now know that many children will remain caries-free for extended periods of time, even without sealants. In the US 1988-91 NHANES-III study (phase 1), about one-third of 12-17 year-olds were caries-free in their permanent dentition. (13) While some children do not need sealants, others do, but they may not all need sealants initially applied at the same point in their lifespan. Once applied, sealants eventually need to be re-applied to continue their effectiveness. Partially retained sealants are less effective than fully retained sealants. (14) It is not known if this repair and re-application process needs to continue for the lifetime of the tooth to continue caries protection. For children and adults at high caries risk, continuous reapplication is probably necessary for continuous protection.

The driving factor for developing methods for targeting children at high risk is the desire for effective and cost-effective use of limited financial and human resources. Since sealants are professionally applied on an individual basis, they are a relatively expensive preventive agent, though very effective. Over the last three decades of research, sealant materials and methods have continued to advance. Recently, Feigal and

colleagues (16) reported improved sealant retention using a bonding agent between the sealant and saliva-contaminated enamel. Sealants are now used for both primary prevention on sound surfaces and therapeutic use on incipient lesions. However, one of the six research priorities listed in 1983 is still relevant, the "Development of low-cost screening methods to identify children at high risk of getting pit and fissure caries."(1)

My charge for this conference was to examine the evidence demonstrating the effectiveness of sealants in high caries risk children and discuss the Research Triangle Institute/ University of North Carolina (RTI/UNC) evidence-based report. (15)

RTI/UNC CRITERIA AND FINDINGS

The RTI/UNC group had several initial criteria for caries management studies:

1) professional provision of intervention

2) in vivo studies

3) having a concurrent comparison group; and

4) using traditional outcome measures of caries experience.

5) the caries risk determination "had been made on an individual subject level based on carious lesion experience and/or bacteriologic testing." High-risk status conferred by group membership, such as a school or community with a high caries rate, or low socio-economic status was not sufficient.

Because of these restrictive criteria, the RTI/UNC investigators' literature search led to only three studies that met their criteria: one study by Heller and colleagues (17) that examined sealant use on tooth surfaces that were sound or had incipient lesions**,** a second study by Sheykholeslam and Houpt (18) that used sealants alone, and a third

study by Zickert and colleagues (19) that used sealants in combination with other preventive agents, (chlorhexidine gel, and 0.2% NaF mouth rinse) in high risk individuals. Consequently, due to the limited number of studies and the limitations in some of the study designs, the RTI/UNC group rated the caries management evidence involving sealants as incomplete.

Methods: Revised Criteria

For this analysis, the criteria have been broadened to better reflect the nature of dental sealant studies, especially with regard to study designs, type of comparison groups and outcome measures. I have included designs that have unsealed teeth or children without sealants as the comparison group, and both prospective and retrospective studies. Outcome measures are usually reported in terms of percent effectiveness, using either a paired or unpaired analysis, or percent sealant retention. Retention and effectiveness are highly correlated. The protocols are often limited to posterior teeth, most frequently, only first permanent molars. Traditional DMFS or DMFT measures are usually not reported.

Since Dr. Rozier was conducting a formal systematic review of dental sealants for this conference **(20 -JDE 2001, this issue**), for discussion purposes, I conducted an English language Medline search and reviewed abstracts to identify additional studies from 1988-2000 not identified by the RTI/UNC evidence report. My prior published dental sealant literature review (2) was used to select earlier studies. These additional studies are summarized in Tables 1 (21-41) and 2 (17, 42-47). Studies in Table 1 utilized a half-mouth design; those with other types of designs are shown in Table 2.

Studies identified by RTI/UNC

The Zickert et al. study (19) demonstrated the effectiveness of a combined preventive regimen that included sealants, chlorhexidine and fluoride mouth rinse, in the highest caries risk group, defined as participants with salivary *S. mutans* levels ≥ 10^6 CFU/ml. However, this study is not a good test of sealant use because of the restrictive selection criteria for sealant application, the lack of baseline occlusal caries data, and the analysis of the combination of preventive regimens did not include a separate evaluation of the effects of the sealant application. Sealant was applied on unfilled, sound surfaces of molars and premolars, but only for a subset of 13-14 year-old children with high salivary *S. mutans* levels at the study's outset. Premolars and first molars may be at lower risk, perhaps due to occlusal anatomy, if they are still sound in this teenage group with high salivary bacterial levels. Results were not reported according to sealant status at baseline or study completion, and information was not presented as to how many teeth were sealed, or the occlusal caries prevalence at baseline (though mean number of decayed approximal and buccal-lingual surfaces were presented).

The Sheykholeslam and Houpt study (18) included children ages 6-10 if "there was evidence of previous dental caries in the mouth, and a pair of contralateral maxillary or mandibular first permanent molar teeth were free of caries." Thus, all the children in this study could be considered at moderate or high risk. The article cited in the RTI/UNC findings presented the results of this study after two years; however, subsequent publications reported results after 33, 48 and 72 months. (29-30) Of the 993 children screened, 205 (20.6%) met the study inclusion criteria, another clue that these children were probably moderate or high caries risk at enrollment. A half-mouth design was

used, with one tooth randomly selected for sealing with an autopolymerized sealant (Delton ®); the other left unsealed. The percent effectiveness in caries reduction from 11 months to six years declined from 90% to 56%. During this time period, sealant retention declined from 92% to 58%, directly related to effectiveness.

The retrospective study by Heller and colleagues (17) compared children who did and did not receive sealants in a school-based program, as well as sealed and unsealed teeth that were initially sound or had incipient lesions. Among surfaces that were initially sound, the five-year decay rate for sealed surfaces was 0.081 and for nonsealed surfaces, 0.125, with an odds ratio of 1.63 (95% CI = 0.63, 4.08; p=.185). Among surfaces that initially had incipient lesions, the comparable rates were 0.108 and 0.518, for sealed and nonsealed surfaces, respectively, with an odds ratio of 8.88 (95% CI=4.56, 17.35; p<.001). Thus, sealants were much more effective in preventing further caries on surfaces that had incipient lesions than initially sound surfaces, providing evidence for successful targeting of children with incipient lesions and the successful therapeutic use of sealant. This study has several limitations: 1) the results are not based on a randomized clinical trial; 2) the comparison group was comprised of children whose parents' did not give consent for sealants, (although it was not reported why parents did not provide consent), and 3) only 20% of children were available for the five-year follow-up including only 17 children in the comparison group. Thus, there may be problems with generalizing the findings.

Determination of Caries Risk and Caries Diagnosis

Caries risk can be considered at the person level or at the tooth level. Presumably, a child at high risk has at least one tooth or tooth surface at high risk,

however, some teeth could be concurrently at low risk (i.e., premolars, teeth with shallow occlusal anatomy). Risk status may change over time because of the age of child, a factor related to the number of exposed tooth surfaces, frequency and duration of cariogenic dietary and bacterial challenges and protective fluoride exposures, the child's immune status (e.g., exposure to antibiotics), salivary flow, oral hygiene and dental office behaviors, number of dental visits, and diagnostic, preventive or restorative services provided.

There is a continuum in the spectrum of risk and disease status and treatment options, from low-risk to high risk, sound to carious, and treatment ranging from none to a sealant applied for primary prevention or therapeutic purposes, to more invasive restorative treatment. Improved caries detection and diagnostic methods would help determine the appropriate cutpoint or threshold separating the clinical decisions to either do nothing or preventively seal, or to therapeutically seal (or use other non-invasive interventions) or surgically treat and restore. A caries detection device such as the Diagnodent, that uses a laser fluorescence system to detect bacterial by-products on the occlusal surface, has been used in Europe for caries management and was recently introduced in the U.S. (48) According to the RTI/UNC report (15), there was only one report assessing this new technique, but sensitivity levels were high compared to radiographic and visual methods. Theoretically, laser fluorescence could be useful for determining whether a tooth is sound and does not require intervention, has evidence of a low level of caries activity and is an appropriate candidate for sealant application, or has a higher level of disease severity that requires surgical intervention. Ideally, it could

subsequently be used to monitor sealant effectiveness to determine if any caries activity beneath the surface has regressed.

In 1991, Handelman (49) reviewed radiographic and bacteriologic studies investigating the therapeutic use of sealants and concluded "caries is inhibited and may in fact regress under intact sealants." Some have raised concern about occlusal radiolucencies beneath sealed surfaces, referred to as hidden caries. (50) The use of a device such as the Diagnodent that potentially could detect caries beneath an unfilled sealed surface could help alleviate this concern. The 1994 federally funded workshop recommended, based on the available evidence and consensus of workshop participants, that teeth with questionable caries or enamel caries be sealed in addition to caries-free teeth determined to be at-risk, and dentin caries be restored. (6)

ADDITIONAL STUDIES: Half-mouth study designs

Many of the first sealant trials used a randomized, half mouth design where children with pairs of eligible, sound, first permanent molars were selected so that one member of the pair could be sealed, and the other molar left unsealed. One or two pairs of sound, first permanent molars were included. If two available sound molar pairs were required, selected children may have been at lower risk than the children who were excluded because some of their first molars had already become carious. Conversely, if no sound molar pairs were available, those children may have been at even higher caries risk and excluded. Studies where children were included if they had one or two pairs of sound molars may include a mix of low and high risk children. The proportion of sound molar pairs available may be a surrogate for caries risk.

Early sealant trials did not specifically discuss caries risk status, but a review of methods indicates that some studies specifically selected children with prior caries experience, either in general, (21-22, 26-27, 33) or pertaining specifically to first permanent molars. There were nine studies identified with randomized, half-mouth designs with unsealed control teeth. Four of them required prior caries experience or excluded children who were caries-free. Thus, the children in these studies all had some caries risk. Five studies included a mixture of children with one or two sound molar pairs or paired and unpaired molars. Thus, these five studies included a mixture of potentially low and high caries risk children.

These studies are shown in Table 1 in chronological order (21-41). Some studies (not in Table 1) such as those by Rock et al. (51) and Rock and Evans (52) required all four first permanent molars to be erupted and caries-free in 6-7 and 8 years olds, respectively. Thus, these children might be at lower caries risk than children who did not have all four molars caries-free. (23-25,43)

McCune and colleagues (23) provided evidence for this hypothesis in their half-mouth study design in Kalispell, Montana. Among 5-8 year olds, about half contributed both first molar pairs and about half had only one sound molar pair eligible. They found that the caries increment was higher in unpaired teeth than paired teeth. Since the counterpart of the unpaired tooth was carious or missing at baseline, the remaining tooth was likely to be more caries susceptible. After one year, using an early ultraviolet light polymerized sealant, full sealant retention was 88% on paired teeth and 80% on sealed teeth; 3% of paired sealed teeth became carious compared to 10% of unpaired sealed

teeth. Children who were ineligible to be in the study because they did not have any sound first molar pairs may have been at even higher caries risk.

Buonocore, (22) the inventor of dental sealants, in one of the first sealant studies, reported two-year results in 1971. His description of tooth selection is informative: *"The permanent teeth selected for this study generally had well-defined pits and fissures or deep fossae, or both, and as a rule were found in mouths in which decay already was present in other teeth. Caries-free individuals with relatively well coalesced occlusal surfaces were not included in the study as it was thought that natural protection against caries existed in such persons. It might be expected, therefore, that the group of surfaces chosen for study could show a somewhat higher caries incidence than an otherwise unselected group."* This study may have been the first sealant trial in high risk children and teeth. After two years, the percent caries reduction compared to unsealed controls was 99% in permanent teeth and 87% in primary teeth.

A study conducted by McCune, Bojanini and Abodeeely (33) used a half-mouth design with 6-8 year old children having at least one pair of caries-free homologous permanent first molars. However, the child had to have at least one carious tooth, indicating that all the children in this study had some caries risk. After three years, the sealant was completely retained on 87% of teeth, and was 85% effective; caries incidence was 8% and 53% on all sealed and unsealed teeth. Among completely sealed teeth, only one tooth developed occlusal caries. Thus, the sealant was very effective in these at-risk children.

Similar selection criteria were used by Brooks, Mertz-Fairhurst and colleagues in their study that compared two types of sealants. (26-27) Caries-free children were

excluded (about half of those screened). Of the at-risk children enrolled and followed for the full time period, the autopolymerized, Delton sealant was more than twice as retentive as the ultraviolet light cured Nuva-Seal. The effectiveness of Delton was 55% after seven-years.

These last two, as well as other studies with half-mouth designs, and included children with one or two pairs of sound, homologous first permanent molars. The proportion of children contributing only one pair may be indicative of at least one member of the other tooth pair being unerupted or carious, depending on the age of the child. The proportion of pairs of caries-free teeth available may be a surrogate measure of the child's caries status, indirectly correlated with caries experience and caries risk. These studies likely included a mix of low and high caries risk children. For example, in a study by Thylstrup and Poulsen, (34-35) after two years, 60% of the 191 children in the study had contributed two molar pairs and 40%, only one molar pair. The children were initially in first grade, about seven years old. The two-year complete retention rate for Concise, a chemically polymerized resin, was 60% overall. For sites remaining fully sealed, partially sealed and unsealed, the percent effectiveness compared to unsealed teeth was 98%, 50% and 10% respectively. Thus, in this study, that may have included as much as 40% of the children with some prior caries experience, sealants were very effective if they were completely retained. Unfortunately, data were not presented stratified by number of tooth pairs per child.

The study in British Columbia by Richardson and colleagues (36-37) used a half-mouth design, to test a pink self-curing sealant on 425 occlusal surfaces of 266 second grade children, 80% of the 532 potentially eligible molars. Thus, a lower percentage of

children in this study may have had prior caries experience. However, teeth were sealed if they were sound or "deemed sticky" because they offered "minor resistance to explorer removal after moderate pressure, without any visual signs of caries." About 12% of sealed teeth had been "sticky." Given our current knowledge, it is not clear if the investigators were identifying precavitated lesions or facilitating them with their explorers. The five-year complete, partial, and no retention rates were 67.4%, 10.3%, and 22.4%, respectively. Overall, the five-year percent effectiveness was 51.2% (after four-years, 62.0% overall effectiveness and 68.5% complete retention). Caries status was not reported by retention rate or initial sound or sticky tooth status. After 30 months, 77.4% of the sticky occlusal surfaces on control teeth became carious or filled. (39)

The studies by Vrbric (40-41) and Charbeneau and Dennison (31-32) were similar. They included 76-81% of the eligible molars, respectively, in similar age groups. The results were also similar, with complete retention of 52%, though the former study was four years and the latter, five years.

Among the nine studies with a half-mouth design, the sealant type and application technique, age of children, selection criteria, sample size, and study duration varied. Results based on percent complete sealant retention indicate that sealant retention began high, and generally, declined over time, regardless of the mix of caries risk participants. This trend is more apparent if longitudinal results of the individual studies are examined. The current effectiveness of sealants is underestimated if based on early sealant trials because the first generation of material used, polymerized by ultraviolet light, was less effective than newer materials and is no longer in use. (4) Retention rate in any sealant trial is also dependent on the accuracy with which examiners can identify the presence of

sealant. Misclassification occurs more often when a clear, compared to opaque resin is used. (53)

Change in Philosophy: Other Study Designs

By 1980, Simonsen (54) reported that it was considered unethical to use homologous, paired teeth as unsealed controls. Most studies after this time utilized other study designs. Seven studies that involved high risk children or teeth are shown in Table 2 (17, 42-47); four are prospective and three are retrospective. Some studies compared sealants on carious vs. non-carious teeth, (42) sealed incipient vs. sound (17) or sealed high risk children or teeth vs. low risk children or teeth (43-45, 47). In retrospective sealant studies, dentists may or may not have selected high risk children for sealant placement, and children were not randomly assigned to a sealed or unsealed group, but sealed and unsealed teeth can be compared in children based on their prior caries experience as a measure of their caries risk status. (43,47) Outcome measures included percent sealant retention, survival rates, (44) caries reduction, (45) or reduction of *S. mutans* levels (46) in teeth sealed in high risk children compared to unsealed or sealed teeth in low risk children.

In 1983, Leverett and colleagues (42) reported the results of a study that used a different type of half-mouth design. The 292 children, initially 6-9 years old, had sealants placed on first molars on one side of the mouth and routine restorative care, as needed on the other side. Both carious and noncarious teeth were sealed, though teeth assigned sealant that had radiographic evidence of caries more than halfway into dentin or proximally were excluded from the study. Retention rate was initially low using the Nuva-Seal, only 52% after one year, and sealant was replaced as needed. (In a later

phase, other sealants were used with 77-86% first year retention.) After four years, sealed surfaces had 74% lower caries increment than unsealed surfaces. The time needed for providing the sealant and restorative services were compared, as were the costs. The benefit cost ratios in both respects were more favorable for caries-active (sealant placed over at least one carious surface) than caries-inactive individuals (sealant placed only on sound surfaces). Based on their findings, they recommended that "sealants should not be used on persons who have not demonstrated past or current caries experience in the occlusal surfaces of permanent first molars." They also cautioned that sealants need to be rechecked and resealed at least annually. This was particularly important because they were using an early generation of sealant with relatively low retention.

More recently, the survival rate of sealed high risk first molars was compared to unsealed low risk first molars in a non-randomized, school-based sealant program in New York. (44) Children were eligible for sealants if they had prior caries experience on primary or permanent teeth. Additional criteria were used to select teeth. Teeth with shallow occlusal anatomy, had proximal or occlusal caries or restoration, or that had been caries-free for four or more years were excluded. Bicuspids were only sealed if there was a clinical impression that they were caries prone. However, if the child's parent or family dentist requested sealant application, the request was honored. The analysis presented was based on 1,122 children between ages seven and nine who were followed up to four years; 65% of tooth sites were sealed, and 35%, unsealed. Comparisons were made between sealed and unsealed sites. There was no control group of children. Although some resealing occurred, four-year retention rates were between 65-82%. Survival analyses for the sealed and unsealed tooth sites (e.g., time to caries or

restoration) was similar for both groups. Cumulative survival rate for four years ranged from .89-.94. The results demonstrated that this targeting approach was effective.

The study by Carlsson and colleagues (45) included a baseline caries risk assessment based on a variety of criteria for the 6-7 year old Swedish children. They identified 121 children at high risk and 83 at low risk. Only the high risk children received a fluoride-containing sealant. After two years, 76.7% of the sealants were completely retained. The caries incidence was not significantly different between the untreated low risk group and the treated high risk group suggesting that the risk classification and sealant treatment were successful. Significantly less enamel caries developed in the sealed group. Though not significant, the caries increment was higher for children who had lost sealants than for those with completely retained sealants, indicating again the importance of sealant repair and replacement as needed. A substudy evaluated salivary *S. mutans* levels at baseline and two years post-sealant use. No significant change during the study period was found.

In contrast, the study by Maas et al. (46) found that sealants reduce *S. mutans* levels up to six months in both low and high risk children. This study included 52 Israeli children, age 6-8 years, divided into low and high caries active groups based on initial deft, plaque index, and occlusal *S. mutans* presence. A half-mouth design was used for sealant application where one side was sealed with Helioseal, a visible light cured sealant, the other side sealed three months later. Children were evaluated again six months from the first visit. The shorter study duration may be partly responsible for the difference in results between this and the Carlsson et al. study. (45)

The study conducted by Weintraub and colleagues (43) was a retrospective patient record analysis of 275 children receiving dental care in a health center for low-income families. A lifetable analysis was conducted to compare the probability of survival (restoration-free tooth years) and cost incurred to first molars of children receiving no sealants, any sealants, or sealants on all first molars. Among children with sealants, comparisons were also made between sealed and unsealed teeth in children with and without restorations prior to sealant placement. Prior restorations, assumed to be reflective of prior caries experience, was a proxy for identification of high risk children. Unsealed teeth in children with prior restorations had the worst probability of survival, while sealed teeth in children with no prior restorations had a very high probability of survival. Sealing all four molars in eligible children was cost –effective after four years, but relatively expensive. Sealing teeth in children with prior restorations achieved cost savings within four to six years, indicating that these high risk children should be given a high priority for sealant application.

Another study by Weintraub and colleagues (47) evaluated the claims data from a retrospective cohort of 15,438 children enrolled in the North Carolina Dental Medicaid program from 1985 to 1992. In this low-income population, over an eight year period, 23% of children received at least one sealant and 33% at least one caries-related service involving the occlusal surface of first permanent molars (CRSO). Sealants were effective in preventing CRSO in this low-income population. Figure 1 (from authors based on data in 50) shows net cumulative costs (sealant costs per molar minus the expected difference in CRSO costs from getting the sealant) under the scenario that children had their molars sealed at age five. Expenditure savings were achieved among children with two or more

prior restorations (the highest risk group) after two years, at age seven. These savings peaked at age nine, but were reduced in subsequent years as sealant effectiveness declines over time if not repaired or replaced. For the middle risk children (one prior restoration), net cumulative costs reached a minimum at age nine of roughly $2.00, but then increased slightly. Placing sealants in this group would be economically beneficial if the payer thinks it is worth spending two dollars per molar to prevent a restoration up to age nine for Medicaid eligible children.

The results of these studies show that sealants are more effective from a cost and time perspective if placed on high risk rather than low risk children, though it may take several years for savings to accrue. Approaches to target high risk children for sealants were successful in balancing their caries incidence or survival rate compared to unsealed low risk children. Except for recent studies that have used salivary bacterial levels, most studies have used evidence of prior or current caries as a critical component of their caries risk assessment method. From my perspective, ideal caries risk assessment methods should predict risk prior to any clinical caries experience.

At the person level, different risk assessment methods may be needed for individuals with and without caries-experience, for different age groups (e.g., primary, permanent and mixed dentitions with varying numbers of teeth or surfaces at risk) and for predicting pit and fissure vs. smooth surface caries. At the tooth level, improved early caries detection methods for occlusal caries would aid the clinicians' decisions to select the appropriate interventions and improve their ability to target teeth that would derive the most benefit from sealants.

CONCLUSIONS

1. Sealants are very effective in preventing pit and fissure caries if completely retained on the tooth surface.
2. Most sealant studies have included low risk children (all four first molars of young children were caries-free), high risk children (prior caries experience required for study eligibility or sometimes evident by the proportion of caries-free tooth pairs available for study inclusion), or a mixture of both low and high risk children. However, analyses may not have been conducted stratified by caries risk status. Sealants have been effective to varying degrees in all of these studies.
3. There is evidence that sealants are more effective in preventing further caries and providing cost savings in a shorter time span if placed in children (or on teeth) with high caries risk compared to children with low caries risk.
4. Most caries risk assessment methods used in these studies have relied on past or current caries experience. Caries risk assessment methods are needed to predict high risk, prior to clinical caries development, so that sealants can be used to prevent caries on all susceptible teeth throughout life.
5. The strict RTI/UNC protocol limited the number of sealant studies that could be included in their review. When studies with other outcome measures are included, there is good evidence that sealants can be used efficaciously and effectively in high risk children as long as the sealant is retained. Although study designs and outcome measures vary, the results across studies are consistent.

REFERENCES

1. National Institutes of Health. Consensus development conference statement on dental sealants in the prevention of tooth decay. J Am Dent Assoc 1984;108:233-36.

2. Weintraub JA. The effectiveness of pit and fissure sealants. J Public Health Dent 1989;49(5 Spec Iss):317-30.

3. Ripa LW. The current status of pit and fissure sealants. J Canad Dent Assoc 1985;(5):367-80.

4. Ripa LW. Sealants revisited: An update of the effectiveness of pit-and-fissure sealants. Caries Res 1993;27(supp):77-82.

5. Llodra JC, Bravo M, Delgado-Rodfiquez M, Baca P, Galvez R. Factors influencing the effectiveness of sealants – a meta analysis. Community Dent Oral Epidemiol 1993;21:261-8.

6. Siegal MD, Kumar JV. Workshop on guidelines for sealant use: Preface (followed by the recommendations.) J Public Health Dent 1995;55(5 Spec Iss):261-73.

7. U.S. Department of Health and Human Services. Oral Health in America: A report of the Surgeon General. Rockville, MD: U.S. Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000.

8. Kaste LM, Selwitz RH, Oldakowski RJ, Brunelle JA, Winn DM, Brown LJ. Coronal caries in the primary and permanent dentition of children and adolescents 1-17 years of age: United States, 1988-1991. J Dent Res 1996; 75(Spec):631-41.

9. U. S. Department of Health and Human Services, Public Health Service. Healthy People 2000: National Health Promotion and Disease Prevention Objectives. DHHS pub no. (PHS) 91-50213. Washington, DC:US Government Printing Office, 1990.

10. U. S. Department of Health and Human Services. Healthy People 2010. Available on the website:
http://www.health.gov/healthypeople/document/html/volume2/21oral.htm#_Toc489700409

11. Dental Health Foundation. The oral health of California's children, A neglected epidemic. 1997.

12. U.S. General Accounting Office. Oral Health. Dental disease is a chronic problem among low-income populations. April 2000. Pub. No. GAO/HEHS-00-72. Washington, D.C.

13. Brown LJ, Kaste LM, Selwitz RH, Furman LJ. Dental caries and sealant usage in U.S. children, 1988-91. J Am Dent Assoc 1996;127:335-43.

14. Ismail AI, Gagnon P. A longitudinal evaluation of fissure sealants applied in dental practices. J Dent Res 1995;74(9):1583-90.

15. Bader JD, Shugars DA, Rozier G, Lohr KN, Bonito AJ, Nelson JP, et al. Diagnosis and management of dental caries. Evidence report, vol. 1: chapters 1-6. Chapel Hill: Research Triangle Institute-University of North Carolina at Chapel Hill; 2000 August 18, 2000. Report No.: Contract No. 290-97-0011, No. 6 and RTI Project No. 6919-006.

16. Feigal RJ, Musherure, Gillespie B, Levy-Polack M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: A clinical study of two-bottle and single-bottle systems. J Dent Res 2000;79(11):1850-56.

17. Heller KE, Reed SG, Bruner FW, Eklund SA, Burt BA. Longitudinal evaluation of sealing molars with and without incipient dental caries in a public health program. *J Public Health Dent*. 1995;55:148-153.

18. Sheykholeslam Z, Houpt H. Clinical effectiveness of an autopolymerized fissure sealant after 2 years. Community Dent Oral Epidemiol. 1978;6:181-4.

19. Zickert I, Emilson CG, Krasse B. Effect of caries preventive measures in children highly infected with the bacterium Streptococcus mutans. Archs Oral Biol 1982;27:861-8.

20. Rozier, RG. Effectiveness of methods for the primary prevention of dental caries: A review of the evidence. J Dental Ed 2001; **THIS ISSUE**.

21. Buonocore M. Adhesive sealing of pits and fissures for caries prevention, with use of ultraviolet light. J Am Dent Assoc 1970;80:324

22. Buonocore MG. Caries prevention in pits and fissures sealed with an adhesive resin polymerized by ultraviolet light: a two-year study of a single adhesive application. J Am Dent Assoc 1971;82:1090-93.

23. McCune RJ, Horowitz HS, Heifetz SB, Cvar, J. Pit and fissure sealants: one-year results from a study in Kalispell, Montana. J Am Dent Assoc 1973;87:1177-80.

24. Horowitz HS, Heifetz SB, Poulsen S. An overview of results after four years in Kalispell, Montana. J Prev Dent 1976;3(3):38-49.

25. Horowitz HS, Heifetz SB, Poulsen S. Retention and effectiveness of a single application of an adhesive sealant in preventing occlusal caries: final report after five years of a study in Kalispell, Montana. J Am Dent Assoc 1977;95:1133-9.

26. Brooks JD, Mertz-Fairhurst EJ, Della-Giustina VE, Fairhurst CW, Williams JE. A comparative study of the retention of two pit and fissure sealants: One-year results. J Prev Dent 1976;3(5):43-46.

27. Mertz-Fairhurst EJ, Fairhurst CW, Williams JE, Della-Giustina VE, Brooks JD. A comparative clinical study of two pit and fissure sealants: 7-year results in Augusta, GA. J Am Dent Assoc 1984;109:252-5.

28. Houpt M, Sheykholeslam Z. The effectiveness of Delton fissure sealant after one year. J Dent Child 1978;24:130-2.

29. Houpt M and Shey Z. Clinical effectiveness of an autopolymerized fissure sealant (Delton) after thirty-three months. Pediatr Dent 1979;1(3):165-8.

30. Houpt M, Shey Z. The effectiveness of a fissure sealant after six years. Pediatr Dent 1983;5(2):104-106.

31. Charbeneau GT, Dennison JB, Ryge G. A filled pit and fissure sealant: 18-month results. J Am Dent Assoc 1977;95:299-306.

32. Charbeneau GT, Dennison JB. Clinical success and potential failure after single application of a pit and fissure sealants: a four-year report. J Am Dent Assoc 1979;98:559-64.

33. McCune RJ, Bojannini J, Abodeely RA. Effectiveness of a pit and fissure sealant in the prevention of caries: three-year clinical results. J Am Dent Assoc 1979; 99:619-23.

34. Thylstrup A, Poulsen S. Retention and effectiveness of a chemically polymerized pit and fissure sealant after 12 months. Comm Dent Oral Epidemiol 1976;4:200-4.

35. Thylstrup A, Poulsen S. Retention and effectiveness of a chemically polymerized pit and fissure sealant after 2 years. Scand J Dent Res 1978;86:21-24.

36. Richardson AS, Gibson GB, Waldman R. Chemically polymerized sealant in preventing occlusal caries. J Canad Dent Assoc 1980;4:259-60.

37. Richardson AS, Gibson GB, Waldman R. The effectiveness of a chemically polymerized sealant: Four-year results. Pediatr Dent 1980;2(1):24-6.

38. Gibson GB, Richardson AS, Waldman R. The effectiveness of a chemically polymerized sealant in preventing occlusal caries: five-year results. Pediatr Dent 1982;4(4):309-10.

39. Gibson GB, Richardson AS. Sticky fissure management – 30 month report. J Canad Dent Assn 1980;4:155-7.

40. Vrbic B. Retention of fissure sealant and caries reduction. Quintessence Int 1983;4:421-4

41. Vrbic V. Five-year experience with fissure sealing. Quintessence Int 1986;17(6):371-2.

42. Leverett DH, Brenner CM, Handelman SL, Iker HP. Use of sealants in the prevention and early treatment of carious lesions: cost analysis. J Am Dent Assoc 1983;106:39-42.

43. Weintraub JA, Stearns SC, Burt BA, Beltran E, Eklund SA. A retrospective analysis of the cost-effectiveness of dental sealants in a children's health center. Soc Sci Med 1993;36:1483-93.

44. Kumar JV, Cavila ME, Green EL, Lininger LL. Evaluation of a school-based sealant program in New York State. Public Health Management Practice 1997;3(3):43-51.

45. Carlsson A, Petersson M, Twetman S. 2-year clinical performance of a fluoride-containing fissure sealant in young schoolchildren at caries risk. Am J Dent 1997 Jun;20(3):115-9.

46. Maas E. Eli I, Lev-Dor-Samovici B, Weiss EI. Continuous effect of pit and fissure sealing on *S. mutans* presence in situ. Pediatr Dent 1999;21:164-8.

47. Weintraub JA, Stearns SC, Rozier RG, Huang C-C. Treatment outcomes and costs of dental sealants among children enrolled in Medicaid. Am J Public Health. In press.

48. Featherstone JDB. Caries detection and prevention with laser energy. Dental Clinics of North America 2000;44(4):955-69.

49. Handelman SL. Therapeutic use of sealants for incipient or early carious lesions in children and young adults. Proc Finn Dent Soc 1991;87(4):463-75.

50. Weerheiijm KL, Groenn HJ, Bast AJ, Kieft JA, Eijkman MA, van Amerongen WE. Clinically undetected occlusal dentine caries: a radiographic comparison. Caries Res 1992;26:305-9.

51. Rock WP, Gordon PH, Bradnock G. The effect of operator variability and patient age on the retention of fissure sealant resin. Br Dent J 1978;145:72-75.

52. Rock WP, Evans RIW. A comparative study between a chemically polymerized fissure sealant resin and a light cured resin. Br Dent J 1982;152:232-4.

53. Rock WP, Potts AJ, Marchment MD, Clayton-Smith AJ, Galuszka MA. The visibility of clear and opaque fissure sealants. Br Dent J 1989;167(11):395-6.

54. Simonsen RJ. The clinical effectiveness of a colored pit and fissure sealant at 24 months. Ped Dent 1980;2(1):10-16.

TABLES AND FIGURE

Table 1: Pit and Fissure Sealants in High Risk Children: Half-mouth Study Design

Table 2: Pit and Fissure Sealants in High Risk Children: Other Study Designs

Figure 1: Net Cumulative Costs for Sealants by Prior Caries Related Service involving the Occlusal Surface (Assuming sealant placement at age 5) in the North Carolina Medicaid Program.